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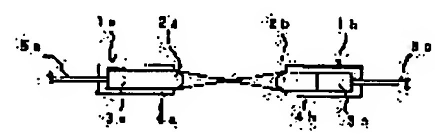
(54) MICROMINIATURIZED BEAM OPTICAL COUPLER

(57)Abstract:
PURPOSE: To provide a microminiaturized beam coupler which is microminiaturized in light beam diameter and is small in coupling loss in a wavelength region of a wide band by constituting the optical coupler by using optical fiber collimators combined with single mode optical fibers and spherically ended distributed refractive index self-converging lenses.
CONSTITUTION: The optical fiber collimators 1a, 1b are respectively composed by integrating the spherically ended distributed refractive index self-converging lenses 2a, 2b, glass rods 3a, 3b, sleeves 4a, 4b and the optical fibers 5a, 5b. The optical fiber collimators 1a and 1b are fixed to face each other in a symmetrical form in such a manner that the beam emitted from the optical fiber collimator 1a focuses once and is then made incident on the optical fiber collimator 1b after spreading. The distance between the lenses is set at ≤10mm and the min. light beam diameter between the lenses is set at ≤ 50μm. Plural optical filters having different characteristics are arranged within the plane of one sheet of the substrate at the focal position of the emitted light beam.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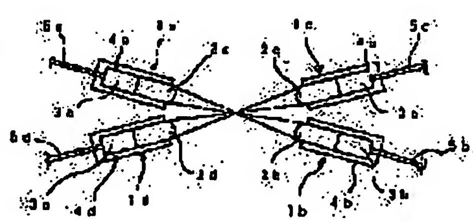
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CLAIMS

[Claim(s)]
[Claim 1] The micrifying beam optical coupling machine with which the optical fiber collimator which has the refractive-index distribution self-focusing lens by which point ball processing was carried out, and a single mode optical fiber, and has the structure where the light beam which carries out outgoing radiation from said lens turns into a convergence beam is characterized by the pair or two or more pairs of things which were countered.
[Claim 2] The micrifying beam optical coupling machine according to claim 1 which sets in the above-mentioned micrifying beam optical coupling vessel, and is characterized by the diameter of the minimum-in distance between lenses light beam between 10mm or less and this lens being 50 micrometers or less.
[Claim 3] The micrifying beam optical coupling machine according to claim 1 characterized by having arranged the optical filter which has the property that plurality differs in the flat surface of one substrate in the above-mentioned micrifying beam optical coupling machine in the focal location of the light beam which carried out outgoing radiation from the optical fiber collimator.
[Claim 4] The micrifying beam optical coupling machine according to claim 1 characterized by having arranged the liquid crystal substrate in the above-mentioned micrifying beam optical coupling machine in the focal location of the light beam which carried out outgoing radiation from the optical fiber collimator.
[Claim 5] The micrifying beam optical coupling machine according to claim 1 characterized by having arranged the optical filter from which a wavelength property changes with the passage locations of a light beam to the focal location of the light beam which carried out outgoing radiation from the optical fiber collimator continuously in the above-mentioned micrifying beam optical coupling machine.
[Claim 6] The micrifying beam optical coupling machine according to claim 1 characterized by having arranged the strange bandpass optical filter with good wavelength constituted with the combination of liquid crystal, a dielectric, or the metal vacuum evaporationo film in the focal location of the light beam which carried out outgoing radiation from the optical fiber collimator in the above-mentioned micrifying beam optical coupling machine.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the configuration of a micrifying beam optical coupling machine especially with little joint loss to an optical fiber about an optical coupling machine.
[0002]
[Description of the Prior Art] The optical coupling machine which combines light using two lenses between optical fibers from the former is used as an element circuit which constitutes an optical switch, various kinds of optical directional couplers, optical multiplexing splitters, etc. Among various kinds of above-mentioned element circuits, in order to make switching speed of light quick in the optical switching components using an acoustooptics modulation element, the approach of narrowing down the diameter of a light beam in an acoustooptics modulation element medium with a lens is adopted. Moreover, also in the light pulse tester for detecting the fracture point of the optical fiber in an optical-fiber-transmission way, a part of optical switch with which the above-mentioned acoustooptics modulation element was inserted between optical fiber lens conjugate diameters of the pelvic inlet using the optical fiber and the lens is used.
[0003] Drawing 9 is drawing having shown an example of the optical switch used conventionally, and the light pulse which carried out outgoing radiation from the laser diode which is not illustrated is changed into parallel light through the lens 73 of the optical-fiber collimator 71, carries out incidence to the acoustooptics crystal 75, it is ****(ed) with the lens 81 of the optical fiber collimator 79 connected to the optical-fiber-transmission way 77 which is a device under test, and is combined. The reflected light from the fracture point on the optical-fiber-transmission way 77 and the node of the optical fiber collimator 79 and this transmission line 77 By carrying out incidence to the acoustooptics crystal 75 again, and impressing the signal from RF generator 89 to the substrate electrode 85 and the up electrode 87 of tolan DEYUSA 83 which were prepared in the end face of said acoustooptics crystal 75 in this case A supersonic wave transmits to the acoustooptics crystal 75 from a transducer 83, the diffraction grating by the refractive-index difference is made to generate in the acoustooptics crystal 75 by this supersonic vibration, and the reflected light from said optical fiber collimator 79 diffracts, and combines with the optical fiber collimator 91. Generally, said optical fiber collimator 91 is connected to the ABARANSHU photodiode, and the light-receiving signal which is the reflected light from the fracture point of the optical-fiber-transmission way 77 is outputted by photo electric conversion as an electrical signal, and can detect existence of the fracture point and its part.
[0004] However, in the conventional optical fiber lens coupled systems, since the lens single as a lens was used, while it was very difficult to constitute low loss optical fiber lens coupled systems to broadband wavelength, in order to raise switching speed, when the diameter of a light beam was made extremely small, there was a trouble that the joint loss to an optical fiber tends to become large. Moreover, generally the diameter of a light beam in the acoustooptics crystal 75 was able to be micrified only in 1mm - about 0.1mm.
[0005] Since the ball lens was used for what there are some which were indicated by JP,60-57564,B and

JP,2-124502,A, for example as an optical fiber collimator by which the conventional proposal is made, and was indicated with these official reports as a lens, spherical aberration and chromatic aberration were comparatively large, and when a single mode optical fiber was used as an optical fiber, it was very difficult [it] to realize the optical coupling machine of low loss in two waves, 1.31 micrometers and 1.55 micrometers.
[0006] Furthermore, although the configuration of the optical coupling machine which point ball processing is carried out [machine] and makes the tip of an optical fiber counter JP,62-206504,A was indicated, since a beam was a Gaussian beam and had a beam divergence angle, implementation of the optical coupling machine which can take the distance between point ball optical fibers 10mm or more since the core diameter of a single mode optical fiber has only the magnitude which is 5-10 micrometers had the trouble of being impossible.
[0007] Namely, it sets in various optical coupling vessels by which the conventional proposal is made. (1) Reservation with a required in order to realize the optical passivity device of arbitration distance [between lenses] of 10mm or more, (2) Achievement of convergence of the beam diameter for closing high-speed light switching operation, such as an ultrasonic light modulation optical switch, if of 50 micrometers or less, (3) It was impossible to realize joint loss of 1.5dB or less to coincidence in two waves, 1.31 micrometers, 1.55 etc. micrometers, etc., to realize all [more than], or for it to have been satisfied.
[0008]
[Objects of the Invention] This invention is made in order to remove the conventional trouble which was mentioned above, the distance between lenses of 10mm or more secures it, and the beam diameter aims at offering achievement of convergence of 50 micrometers or less, and the light beam coupler which can realize joint loss of 1.5dB or less to coincidence in two waves.
[0009]
[Summary of the Invention] In order to attain the above-mentioned purpose, the optical fiber collimator which invention according to claim 1 has the refractive-index distribution self-focusing lens by which point ball processing was carried out, and a single mode optical fiber, and has the structure where the light beam which carries out outgoing radiation from said lens turns into a convergence beam is characterized by the pair or two or more pairs of things which were countered. Invention according to claim 2 is added to said first means, and is characterized by the diameter of the minimum-in distance between lenses light beam between 10mm or less and this lens being 50 micrometers or less. Invention according to claim 3 is characterized by having arranged the optical filter which has the property that plurality differs in the flat surface of one substrate in the focal location of the light beam which carried out outgoing radiation from the optical fiber collimator in addition to said first means.
[0010] Invention according to claim 4 is characterized by having arranged the liquid crystal substrate in the focal location of the light beam which carried out outgoing radiation from the optical fiber collimator in addition to said first means. Invention according to claim 5 is characterized by having arranged the optical filter from which a wavelength property changes with the passage locations of a light beam to the focal location of the light beam which carried out outgoing radiation from the optical fiber collimator continuously in addition to said first means. Invention according to claim 6 is characterized by having arranged the strange bandpass optical filter with good wavelength constituted with the combination of liquid crystal, a dielectric, or the metal vacuum evaporationo film in the focal location of the light beam which carried out outgoing radiation from the optical fiber collimator in addition to said first means.
[0011]
[Example] Hereafter, this invention is explained to a detail based on the example shown in the drawing. Drawing 1 (a) is drawing showing one example of the micrifying beam optical coupling machine concerning this invention, and consists of two pairs of optical fiber collimators. In this drawing, Signs 1a and 1b are optical fiber collimators, and this optical fiber collimator unifies and constitutes point ball refractive-index distribution self-focusing lens 2a, 2b, glass rods 3a and 3b, Sleeves 4a and 4b, and optical fibers 5a and 5b, respectively. After the beam which carried out outgoing radiation connects a focus once and spreads from optical fiber collimator 1a, it is fixed face to face in a symmetrical form so

that incidence may be carried out to optical fiber collimator 1b, and the optical fiber collimators 1a and 1b constitute the optical coupling machine. Drawing 1 (b) is drawing showing other examples of the micrifying beam optical coupling machine concerning this invention, and shows the case where four optical fiber collimators [1a-1d] pairs constitute an optical coupling machine.

[0012] Drawing 2 is drawing showing one example which applied the micrifying beam coupler concerning this invention to the optical switch using an acoustooptics modulation element. this drawing -- setting -- 11a-11c -- a point ball refraction distribution self-focusing lens, and 12a-12c -- a glass rod, and 13a-13c -- for an acoustooptics modulation element medium and 16, as for an up electrode and 18, a lithium-niobate transducer and 17 are [an optical fiber collimator, and 14a-14c / an optical fiber and 15 / a lower electrode and 19] RF generators. Moreover, the physical relationship of the acoustooptics modulation element medium 15 and each optical fiber collimator serves as an include angle with which the diffracted light diffracted within an acoustooptics modulation element medium is satisfied of black conditions.

[0013] Thus, in the constituted optical coupling machine, outgoing radiation of the beam of light which carried out incidence to optical fiber 14a from the light source which is not illustrated is carried out to the interior of the acoustooptics modulation element medium 15 through glass-rod 12a and point ball refractive-index distribution self-focusing lens 11a which constitute optical fiber collimator 13a. At the time of un-operating, from the acoustooptics modulation element medium 15, RF generator 19 carries out outgoing radiation of this beam as an emission light, and combines it with optical fiber 14b through point ball refractive-index distribution self-focusing lens 11b and glass-rod 12b.

[0014] On the other hand, if said RF generator 19 impresses high frequency electric field between the up electrode 17 of the lithium-niobate transducer 16, and the lower electrode 18 at the time of actuation, the diffraction grating which consists of the condition of the refractive index by the supersonic wave of condensation and rarefaction in the acoustooptics modulation element medium 15 according to an electroacoustic transduction operation of the lithium-niobate transducer 16 will occur. A part of light beam in said acoustooptics modulation element medium 15 is changed by this diffraction grating, the direction of outgoing radiation is changed by diffraction, and it combines with optical fiber 14c. That is, the light beam switching to optical fiber 14c from optical fiber 14a is attained by actuation mentioned above.

[0015] Since the optical coupling machine concerning this invention is using the refractive-index distribution self-focusing lens as a lens, the immobilization in an optical fiber collimator is very easy for it, and it can realize the large optical fiber collimator of small NA. Furthermore, by considering the tip of a rod lens as spherical-surface processing, NA of a lens can be enlarged further, and astigmatism can be improved, and reduction of the joint loss between optical fibers can be effectually attained in a broadband wavelength field. Moreover, since convergence / emission light beam optical system is used, micrifying of the diameter of a light beam in an acoustooptics modulation element also has the description that a degree of freedom is very large.

[0016] As a passive element which can be arranged in the center section of the micrifying beam optical coupling machine concerning this invention, there are various kinds of optical FAIRUTA components and reflective components. drawing having shown the configuration of the filter which can be arranged in the micrifying beam optical coupling vessel which drawing 3 requires for this invention -- it is -- the filter base plate 30 top -- two or more optical filters 31a and 31b of 50-micrometer angle, and ... the example which constituted the hyperfractionation optical filter substrate which carried out set arrangement of the 31n is shown. the optical filters 31a and 31b with which the properties of 400 pieces differ on the filter base plate 30 of 1mm angle, and ... 31n can be integrated and an adjustable wavelength optical filter can be easily constituted by moving a filter base plate mechanically on the optical axis of a micrifying beam optical coupling machine with a screw etc.

[0017] Drawing 4 (a) is drawing having shown the configuration of the reflective mirror 40 using the liquid crystal which can be arranged in the micrifying beam optical coupling vessel concerning this invention, and 41 is [a transparent electrode, and 43a and 43b of liquid crystal, and 42a and 42b] transparence substrates. Thus, it is possible to constitute the liquid crystal optical switch of 2x2 by

inserting the constituted liquid crystal reflective mirror 40 into a micrifying beam optical coupling machine, as shown in drawing 4 (b). That is, when an electrical potential difference is not impressed between transparent electrode 42a and 42b, liquid crystal 41 is in a transparence condition, and the coupled circuit of an optical switch is formed between the optical fiber collimators 1a and 1b and the optical fiber collimators 1c and 1d. Next, if an electrical potential difference is impressed among transparent electrodes 42a and 42b, liquid crystal 41 will serve as an opaque reflective mirror, and the coupled circuit of an optical switch will be formed between the optical fiber collimators 1a and 1d and the optical fiber collimators 1b and 1c. Since it converges the light beam to the level of 20 micrometers in the part of liquid crystal, it is possible to constitute a small optical switch by the very small liquid crystal device. Moreover, since the transmission of liquid crystal 41 can be set as arbitration by adjusting the electrical potential difference impressed among transparent electrodes 42a and 42b, the optical branching coupler which has the branching ratio of arbitration can be constituted only as an optical switch.

[0018] Drawing 5 (a) is drawing having shown the configuration of the wavelength continuation adjustable filter 51 which can be arranged in the micrifying beam optical coupling vessel concerning this invention, and can constitute a strange small optical filter with good wavelength, and an optical multiplexing splitter by inserting this wavelength continuation adjustable filter in a micrifying beam optical coupling machine, as shown in drawing 5 (b). Drawing 6 (a) is drawing showing the configuration of the strange bandpass optical filter 60 with good wavelength using the liquid crystal and the metal membrane which can be arranged in the micrifying beam optical coupling vessel concerning this invention.

[0019] For liquid crystal, and 62a and 62b, in drawing, the transparent electrode film, and 63a and 63b are [61a and 61b / a transparence spacer substrate, and 65a and 65b of a transparence substrate and 64] metal membranes. It becomes the bandpass optical filter which makes the whole tooth space across which it faced by metal membranes 65a and 65b in the condition that the electrical potential difference is not impressed between metal membrane 65a, transparent electrode 64a, and metal membrane 65b and transparent electrode 64b a resonance mold cavity. The bandpass optical filter with which liquid crystal 61a and 61b will serve as an opaque reflective mirror on the other hand if an electrical potential difference is impressed between metal membrane 65a, transparent electrode 64a, and metal membrane 65b and transparent electrode 64b, and the tooth space across which it faced with liquid crystal 61a and 61b serves as a resonance mold cavity is formed. An optical filter switchable two waves can be constituted by inserting such a wavelength adjustable bandpass optical filter in a micrifying beam optical coupling machine, as shown in drawing 6 (b). Next, by using a point ball refractive-index distribution self-focusing lens explains that joint loss of an optical coupling machine is improved in two waves, 1.31 micrometers and 1.56 micrometers, using the count result of the two-dimensional model by the simulation using the beam-of-light locus pursuing method.

[0020] Drawing 7 (a) and (b) calculate the distance between optical fiber collimator lenses in the wavelength of 1.3 micrometers and 1.56 micrometers at the time of using the SELFOC lens of SLW20x0.12P (outer-diameter phi2mm, lens pitch 0.12 pitch) of NA0.46 for spherical-surface processing with a radius of 8mm in a point in the wavelength of 1.3 micrometers as a point ball refractive-index distribution self-focusing lens, respectively, having given, and the relation of optical fiber joint loss.

[0021] In count, it was assumed as a glass rod that it was that in which a light beam carries out outgoing radiation to homogeneity supposing quartz glass with a die length of 4.8mm in the range corresponding to NA0.1 of an optical fiber to an optical fiber, using the single mode optical fiber of the core diameter of 10 micrometers, and 125 micrometers of diameters of a clad as an optical fiber. Furthermore, refractive-index distribution in the SELFOC lens was considered as ideal square distribution. (a) shows the optical fiber joint loss over the wavelength of 1.3 micrometers, and (b) shows the optical fiber joint loss over the wavelength of 1.56 micrometers. In the distance between lenses of 1.315mm, it turns out that 0dB of optical fiber joint loss is attained so that more clearly than drawing.

[0022] Next, the relation of the optical fiber collimator lens in two waves, 1.3 micrometers and 1.56

micrometers, and optical fiber joint loss at the time of using it with flat-surface polish of the SELFOC lens of SLS20x0.15P (the outer diameter of 2mm, lens pitch 0.15 pitch) of NA 0.37 and the refractive-index distributed constant 0.238 (wavelength of 1.3 micrometers) conventionally used by such optical fiber coupler system is shown in drawing 8 (a) and (b) for the optical coupling machine concerning this invention, and an engine-performance comparison. In addition, except for the lens constant, it was presupposed except having used the glass rod as quartz glass with a die length of 4.5mm in this simulation that it is the same as that of the above-mentioned conditions all.

[0023] From drawing 8 (a) and (b), it is shown by the same distance between lenses that only 0.4dB joint loss is acquired to 1.3 micrometers, and distance between lenses cannot set optical fiber joint loss to 0 in two waves although 0dB of joint loss is acquired to 1.56 micrometers by 23.9mm. It became clear that it generated although loss of about 0.4dB is in an ideal condition as mentioned above especially to the wavelength of 1.3 micrometers.

[0024] Next, in order to check an above-mentioned simulation result, the result of having made the optical fiber collimator of the conditions assumed to drawing 7 and drawing 8 as an experiment is explained. In the optical fiber collimator using the point ball refractive-index distribution self-focusing lens used for the invention in this application, 1.2-1.3dB joint loss was acquired to two waves, 1.31 micrometers and 1.55 micrometers, in the location with a distance [between lenses] of 13.5mm. Moreover, in the optical fiber collimator using the flat-surface polish refractive-index distribution self-focusing lens used conventionally, 1.7dB joint loss was acquired to two waves, 1.31 micrometers and 1.55 micrometers, in the location with a distance [between lenses] of 24mm. Since 1dB of optical connecter connection loss is included in the above-mentioned joint loss, the joint loss in an actual lens part is respectively considered to be 0.2-0.3dB and about 0.7dB. Thereby, it was checked by using a point ball refractive-index distribution self-focusing lens for an optical fiber collimator that joint loss of a micrifying beam optical coupling machine is improvable in the wavelength field of a broadband.

[0025]

[Effect of the Invention] Since the micrifying beam optical coupling machine concerning this invention constitutes an optical coupling machine using the optical fiber collimator which combined the single mode optical fiber and the point ball refractive-index distribution self-focusing lens as mentioned above The diameter of a light beam is made to be able to converge on 50 micrometers or less, and a micrifying beam coupler with small joint loss can be realized in a broadband wavelength field, and the effectiveness which was excellent when an acoustooptics modulation optical switch, a high-speed optical filter [various functions small] or a high-speed optical multiplexing splitter, etc. was constituted is demonstrated.

[Translation done.]